Data Needs for Model Evaluation for Ozone and Regional Haze Planning

Gail Tonnesen
EPA Region 8

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Topics

1. Ozone Exceptional Event Demonstrations for Wildfires and Stratospheric Intrusion.
2. Estimates of U.S. Background O3 and international transport of O3.
3. O3 attainment planning and O3 sensitivity to VOC and NOx.
4. Regional Haze planning: estimates of natural visibility and international transport contributions to regional haze.

EPA, State and Tribe Planning Needs

- States, Tribes and EPA use photochemical models to develop Implementation Plans (SIPs, TIPs, or FIPs) that demonstrate:
  - Attainment of National Ambient Air Quality Standards for O3.
  - Good Neighbor SIPs for interstate transport of ozone.
  - Progress toward regional haze goal of natural visibility conditions at Class I Areas.
- Air Quality goals are evaluated for a subset of days:
  - O3 attainment is typically evaluated for the ten highest **modeled** ozone days.
  - Regional haze goal is evaluated for the 20% worst anthropogenic impairment days and for the 20% best visibility days.

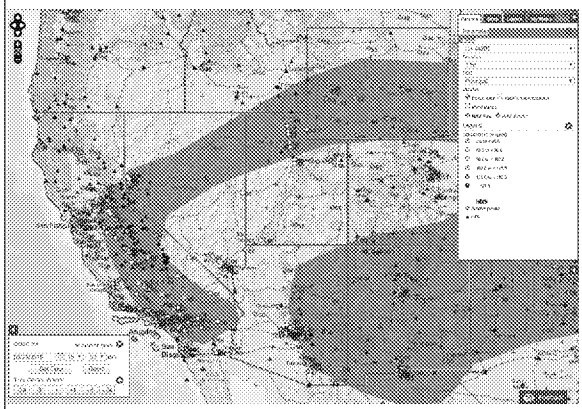
EPA, State and Tribe Planning Needs

- Models should accurately simulate background O3 and natural haze levels on individual days:
  - Background O3 and natural haze levels are highly variable in space and time.
  - Do models accurately represent background O3 and natural haze on the subset of days used for air quality planning?
  - Can the next generation of satellite data help provide more accurate estimates of daily ozone and natural haze?
- Days with high ozone or haze levels caused by Exceptional Events can be excluded from the planning process.
  - For O3, states prepare an exceptional event demonstration for review by EPA.
  - For regional haze, data analysis methods are used to estimate the natural haze level on each day.

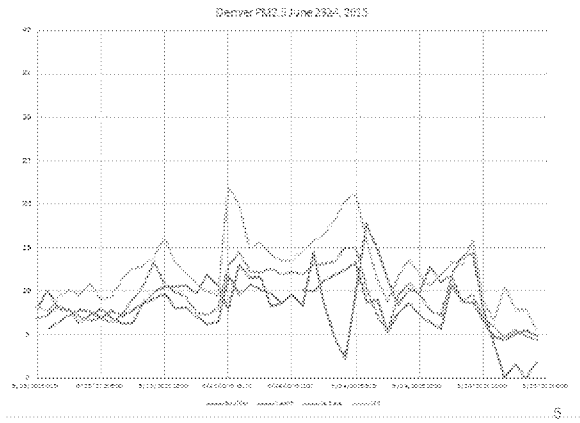
Ozone Exceptional Event Complexity

- Denver O_3, June 23, 2015: 91 ppb (hourly 122 ppb).
- Smoke from California Fires north and Arizona fires south of Denver.
- Urban 8-hour O_3 at 91 ppb was 35 ppb higher than the highest rural site in Colorado, at 56 ppb.
- Smoke impact, if any, is ambiguous.

Wildfire Plumes, June 23, 2015

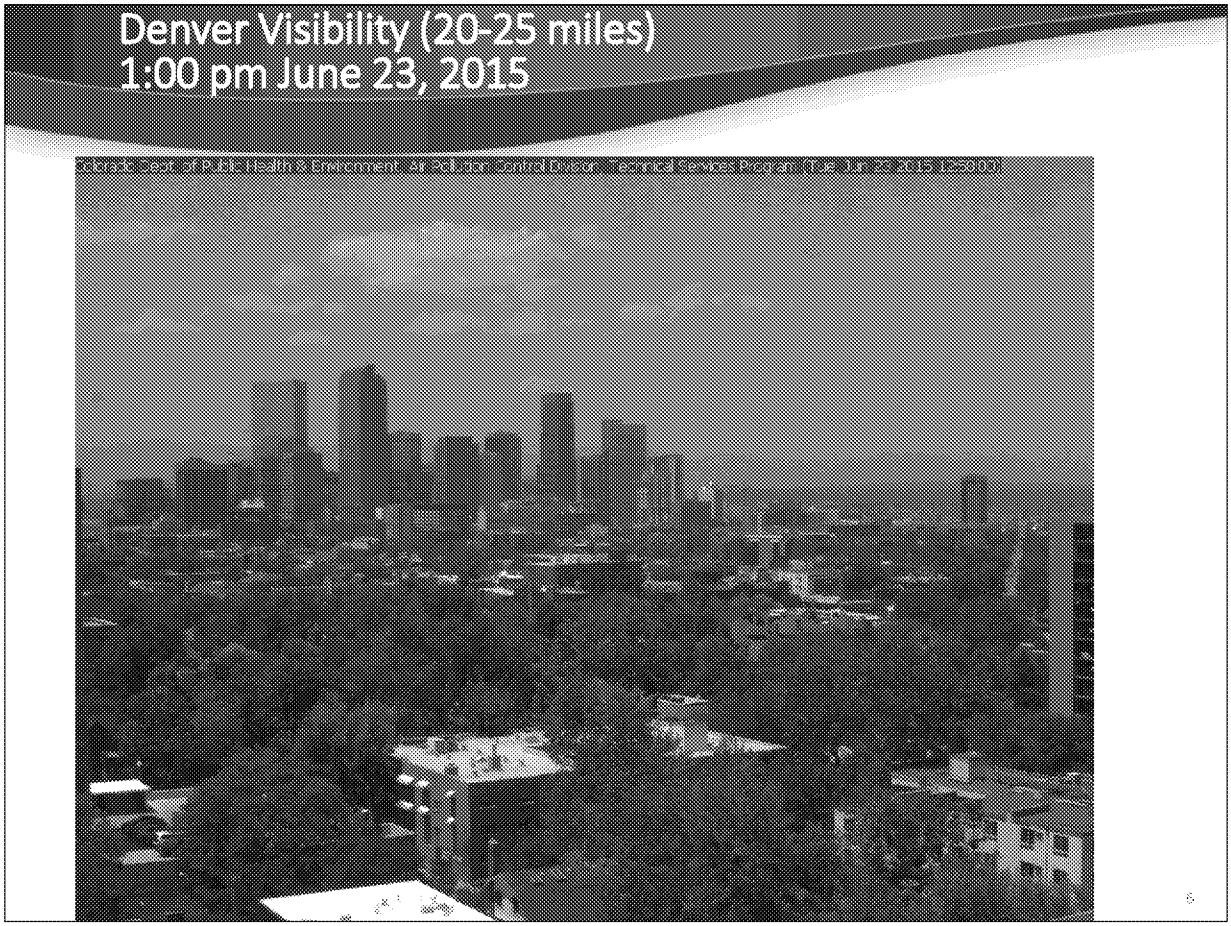


Smoke Impacts on PM_{25}?



MODSIS and GOES data is used to estimate location of smoke plumes.

This example shows the complexities inherent. June 23, 2015 was one of the two highest ozone days in Denver in 2015. Fires were burning in California and Arizona with regional impacts. Satellite imagery on the day showed smoke plumes both north and south of Denver that day. PM2.5 data in Denver was relatively high (for Denver) but generally below 15 ug/m3. the exception was a brand new near-roadway PM2.5 monitor which saw rush hour traffic peaks around 25 ug/m3. Smoke impact in the PM2.5 data was ambiguous. More sophisticated investigation would be needed to say whether smoke impacts were significant in Denver on June 23.



Denver has a state only visibility standard with hourly visibility measurements and imagery. This view from June 23 shows 20 to 25 mile visibility at 1:00 pm. Hazy, but not terribly smoky.

Nested 36/12/4-km Model Domains

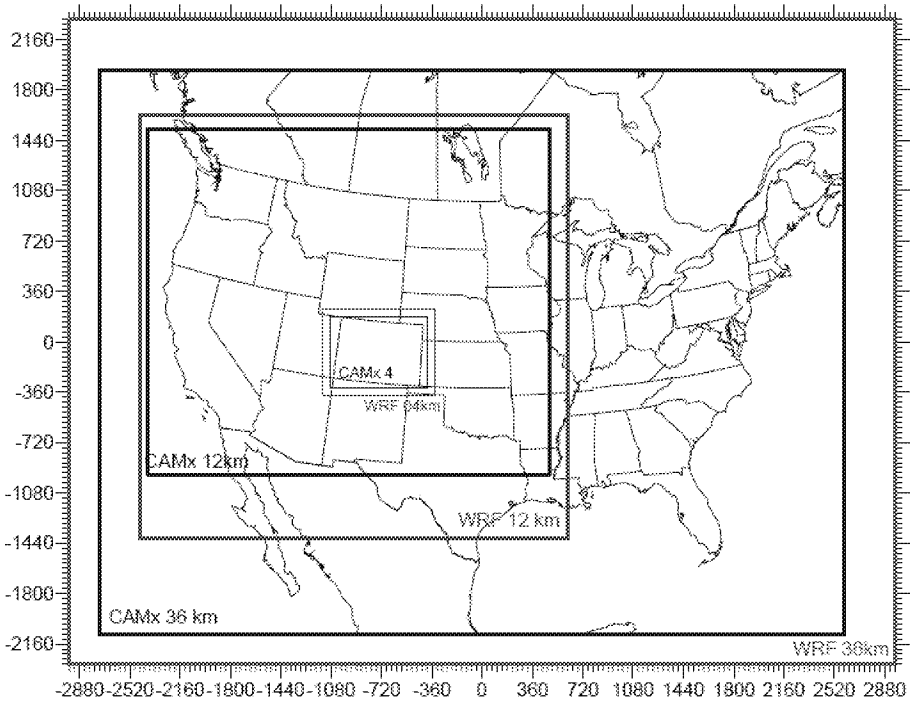
WRF and CMAQ or CAMx

Vertical Grid:

Typically 20 to 40 layers from the surface up to the lower stratosphere at 50 mb.

Lateral BC from Global Models:

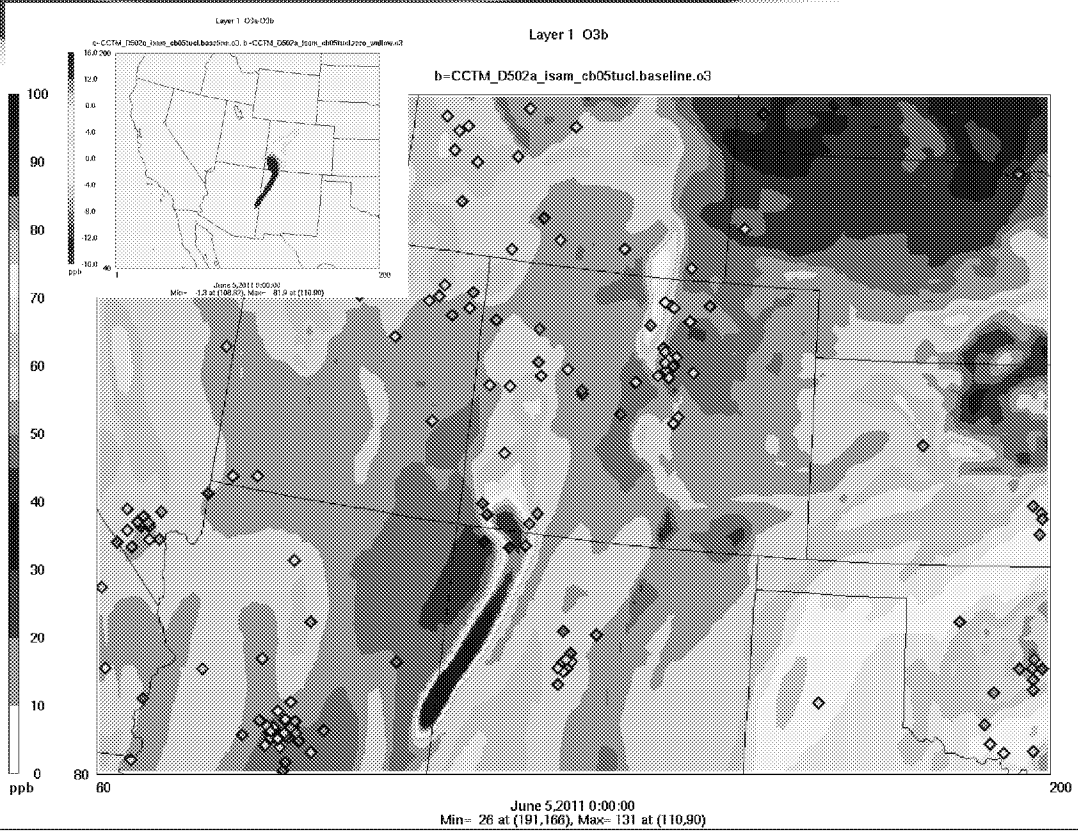
MOZART
GEOS-Chem
AM3
RAQMS



CMAQ simulations for the Wallow Fire, Arizona June 2011

- Photochemical models often over estimate ozone in wild fire plumes:
  - CMAQ simulations for the June 2011 Wallow Wildfire in eastern AZ consistently over predict O3 when the model fire plume overlaps with monitors.
  - CMAQ also predicts very high concentrations of HCHO and higher aldehydes in the fire plume.
  - Baker et al., (2016), Contribution of regional-scale fire events to ozone and PM2.5 air quality estimated by photochemical modeling approaches, Atmospheric Environment 140 (2016) 539-554, http://dx.doi.org/10.1016/j.atmosenv.2016.06.032
- However, O3 monitoring data was not available in the area of the modeled wire fire plume on many days. No aldehyde data available.
- Will TEMPO data be useful for evaluating model performance for wildfires for O3 and its precursors, including HCHO, in areas that lack ambient monitors?

Wallow Fire, Ozone in Layer 1, 5 PM MDT, June 4



Ozone Attainment Planning

- Model evaluation is completed for historical O3 episodes to assess if the model is reliable for projecting future changes in O3.
- The base year O3 design values is calculated at the weighted average of 5 years of the 4th highest daily 8-hour average O3.
- Model ozone relative response factor (RRF) is used to project the future ozone design value.
  - RRF = Future model O3/Base year model O3 (average ratio for the ten highest modeled O3 days.
  - Future O3 design value = (RRF)(Base Year O3 Design value)
  - The Relative Response Factor approach is adopted to correct for model bias.
- The state successfully projects attainment of the O3 NAAQS if the future design value does not exceed the NAAQS.

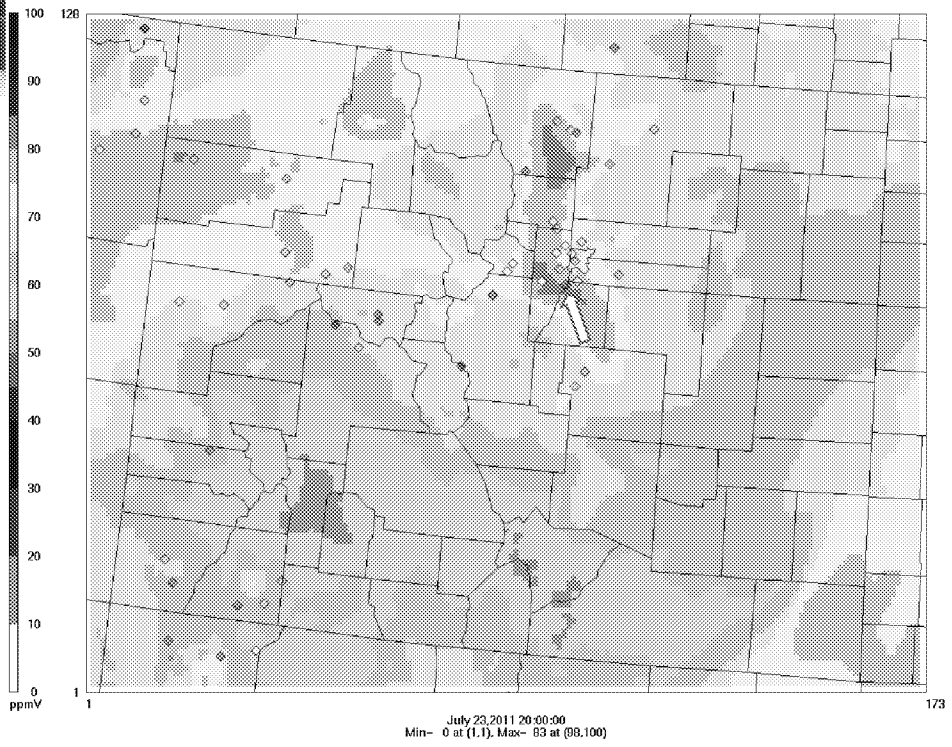
Ozone SIP Modeling

Denver O3 attainment demonstration at the Chatfield monitor.

Highest 10 modeled O3 days						Highest 10 observed O3 days	
Date	2011 Observed	2011 Model	Bias%	2017 Model	RRF 2017/2011	Date	2011 Observed
7/5/2011	69	84	21%	79	0.95	6/24/2011	99
7/12/2011	71	83	17%	78	0.93	6/7/2011	84
8/26/2011	71	83	17%	77	0.93	8/13/2011	84
7/4/2011	63	81	30%	77	0.94	8/12/2011	82
8/3/2011	67	81	21%	75	0.93	8/20/2011	81
7/6/2011	71	80	12%	78	0.97	8/27/2011	81
8/27/2011	81	80	-1%	75	0.94	7/18/2011	79
7/23/2011	73	78	7%	75	0.95	7/30/2011	78
7/29/2011	66	78	18%	71	0.92	6/22/2011	76
8/22/2011	75	78	3%	73	0.93	8/23/2011	76

- Ozone precursors were reduced by about 30%, but the average RRF is 0.94, or 6% reduction in ozone in 2017.
- Model response is stiff because of high background O3 and modeled NOx disbenefits at the Chatfield monitor.
- Can we use satellite data to evaluate the model for both of these effects?

1-hour O3 model and obs at 1 pm LDT July 23, 2011



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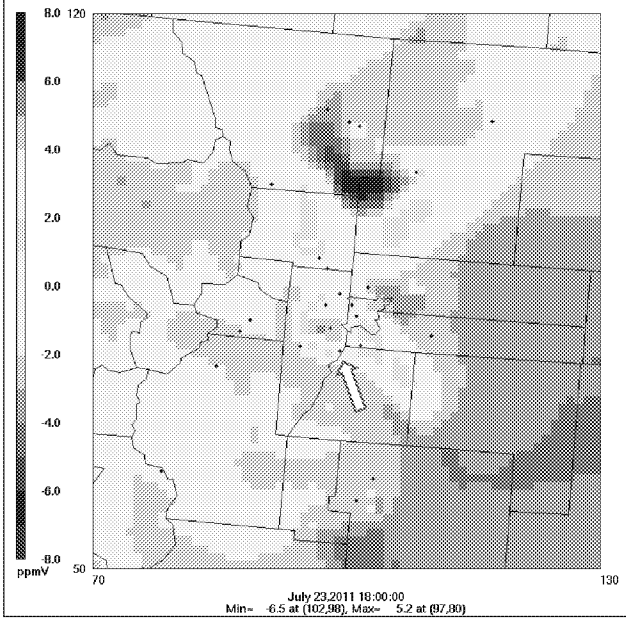
Model performs well in the Denver area but is biased high for regional ozone on July 23.

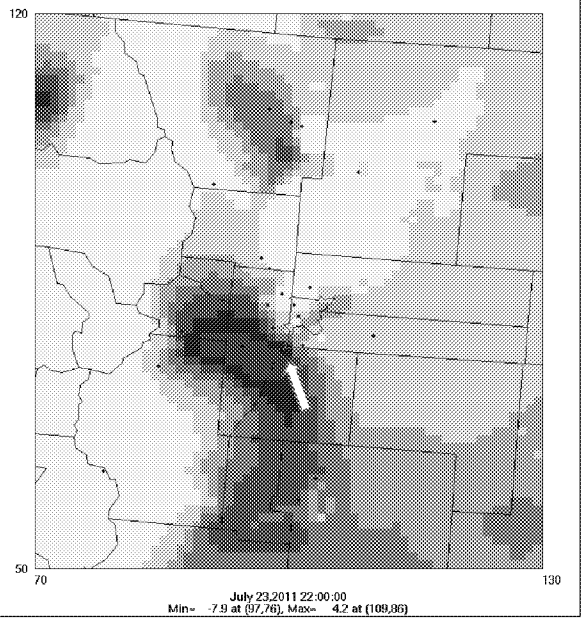
July 23 Model response (2017 – 2011) for 1-hour average O3

Hourly O3 NOx disbenefits in morning and benefits in afternoon. 8-hour average has small benefit.

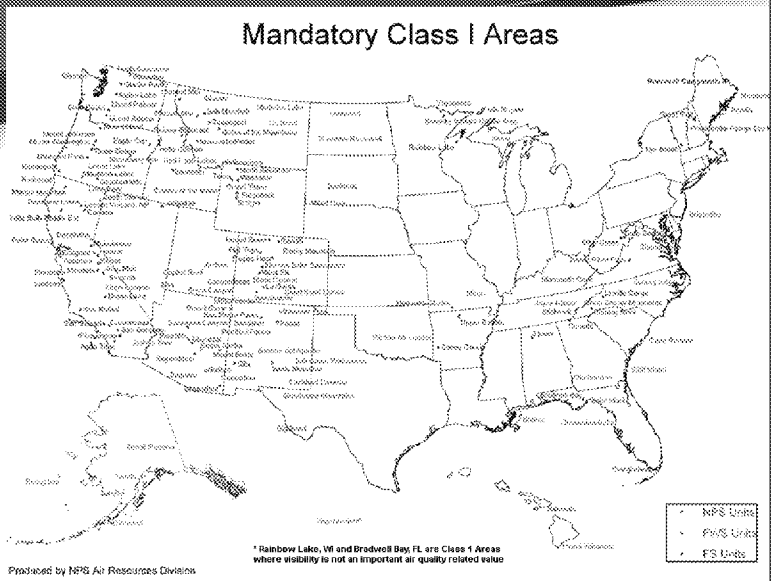
Delta O3 at 11 am LDT



Delta O3 at 3 pm LDT



Regional Haze



- Clean Air Act goal is to achieve natural visibility at Class I areas by 2064.
- Regional haze metrics rely on IMPROVE monitoring data:
  - light extinction: b_{ext} (Mm^{-1})
  - visual range = $3.91/b_{ext}$ (km)
  - deciviews = $10 \ln(b_{ext}/10\ Mm^{-1})$
  - 20 Mm^{-1} = 200 km = 11 dv
- States submit SIPs every 10 years showing progress on improving visibility.
- Regional Haze goal is linear progress in reducing haze (in deciviews) on the worst 20% days and no degradation on the best 20% days.
- Uniform rate of progress (URP) is defined as the slope of the line from baseline worst 20% deciviews to the natural deciviews.
- Model simulations did not show progress below the URP at some western Class I areas, but in the first planning period, modeled progress was evaluated on the 20% worst days that included wildfires.

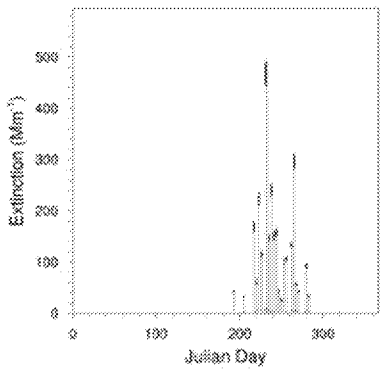
Regional Haze Planning

- EPA has proposed to revise the Regional Haze Rule so that progress and the URP are evaluated for anthropogenic visibility impairment:
  - Goal is to exclude days that are affected by uncontrollable episodic extreme events such as wildfire and dust storms.
  - Visibility Impairment is evaluated relative to natural haze conditions:
    - bext = light extinction (Mm^{-1})
    - Impairment (deciviews) = $10\ \ln(bext_{total}/bext_{natural})$

Old Approach

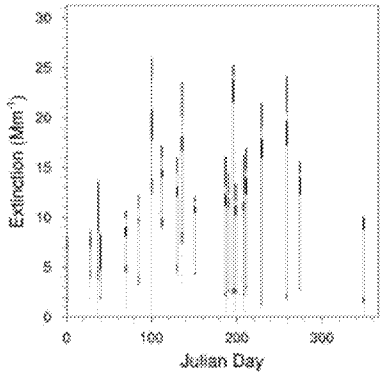
Haze evaluated on the worst 20% visibility days that included wildfires. Max extinction = 500 Mm^{-1}

Sawtooth IMPROVE data 2012



New Approach

Impairment evaluated on the worst 20% days. Max extinction = 26 Mm^{-1}. However, it appears that some days with wildfire contributions are still included.



Regional Haze Planning

- States are not responsible for visibility impairment caused by international transport, but estimates of international transport have large uncertainty.
- Will TEMPO data be useful for day specific estimates of:
  - Natural sources of haze, including wildfires and dust storms.
  - Evaluating international transport of PM2.5 including sulfate, nitrate, and dust.
  - Evaluating modeling performance for both the cleanest days (PM2.5 concentrations less than 1 ug/m3) and the most impaired days.
- TEMPO data could be useful for Regional Haze SIPs that will be due in 2028.

Summary

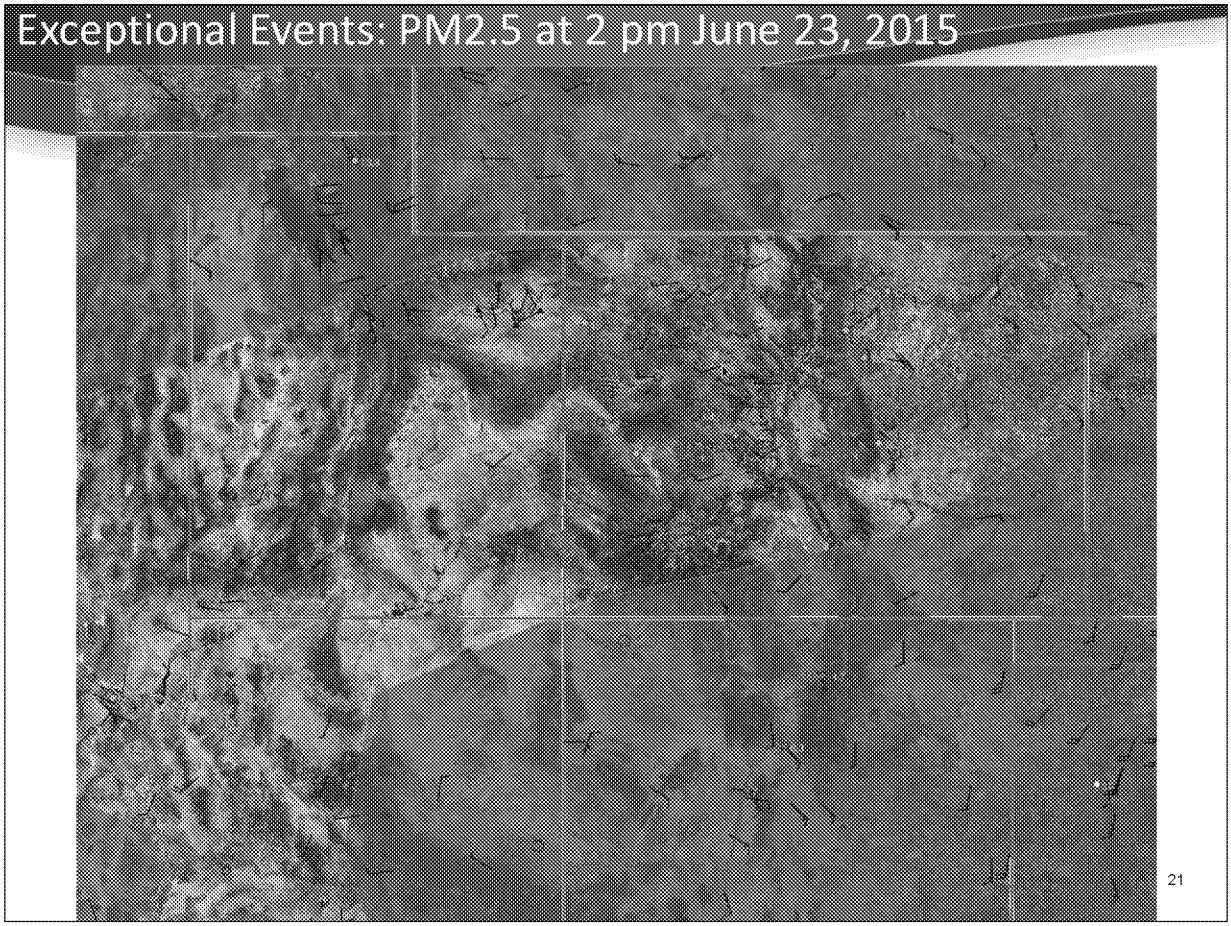
- State, Tribe and Federal Air Quality planners need:
  - High spatial resolution hourly measurements of O3 and precursors for urban O3 planning.
  - Regional scale measurements of O3 and precursors for evaluation of O3 exceptional events and background O3 levels.
  - Measurements of speciated PM to evaluate natural haze levels and international transport of visibility impairing pollutants.

Extra Slides

Table 29 - Design Value Calculations for Select Sites 4th Maximum Values (2009-2013)

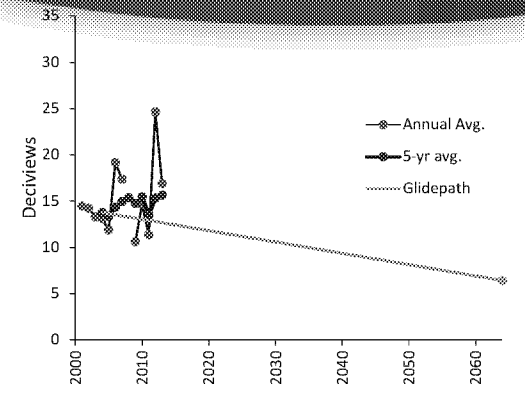
	4th Maximum Daily Ozone Concentration (ppm)			
Year	Chatfield	Rocky Flats-N	NREL	Ft. Collins-W
2009	71	79	68	73
2010	79	76	74	75
2011	82	81	83	80
2012	86	84	81	80
2013	83	85	84	82
3-Year Design Values (DV)				
DV: 2009-2011	77	78	75	76
DV: 2010-2012	82	80	79	78
DV: 2011-2013	83	83	82	80
5-Year Weighted Design Values				
	80.7	80.3	78.7	78.0

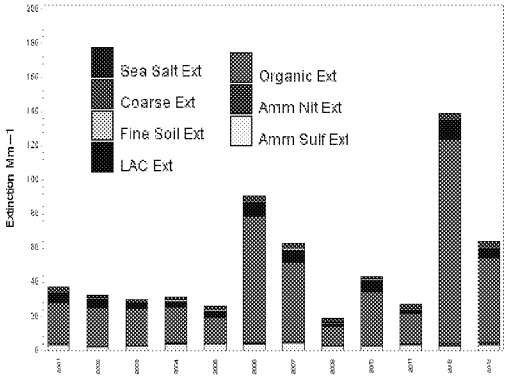
Exceptional Events: Ozone at 2 pm June 23, 2015



PM2.5 seems to be higher in Colorado compared to areas lower in areas u

Regional Haze Planning





Example of tracking progress:

- At Sawtooth Wilderness Area episodic natural events (e.g. wildfires), not anthropogenic emissions, dominate the 20% worst visibility days.
- Can we accurately identify fire contributions to haze for days with small contributions to PM from distant fires?